

# ACT SZ



Tobias Marriage  
Princeton Univ.

May 9, 2007

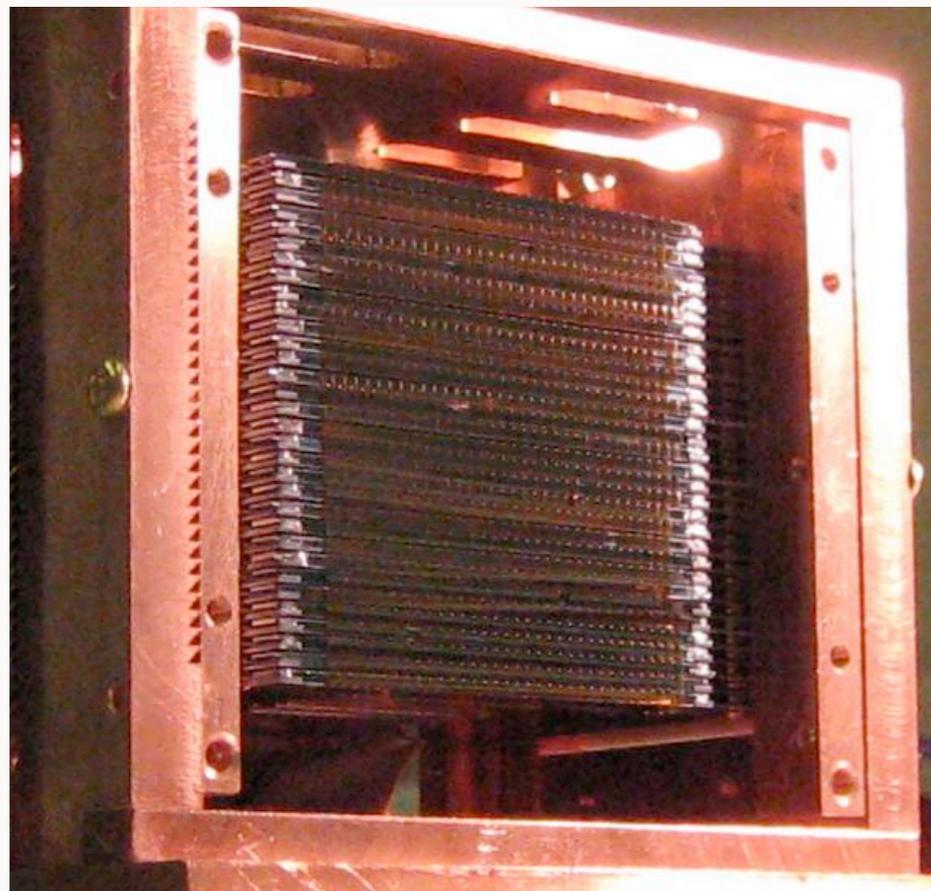
The Warm & Hot  
Universe

# OUTLINE

- Technology: The ACT Camera
- TSZ and KSZ Detection
- Observations and Preliminary Results

# FOCAL PLANE EVOLUTION

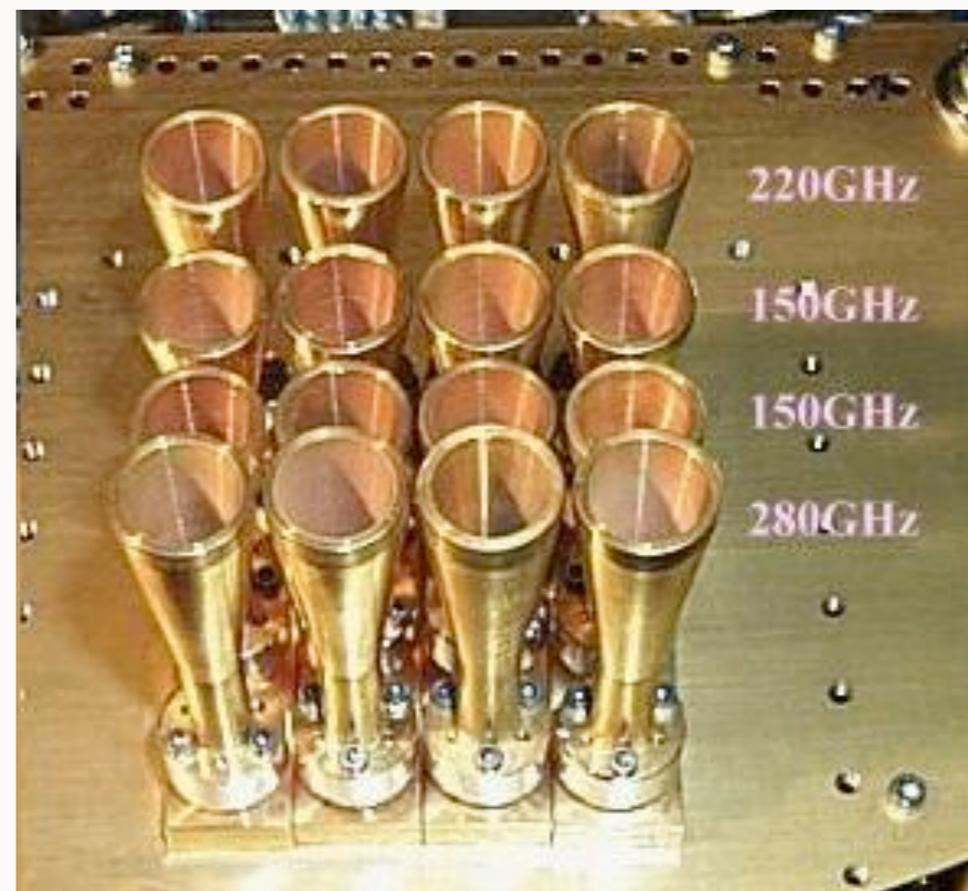
ACT



2007: 1000 x 150 GHz

(ACT 2008: 1000 x 150 GHz, 1000 x 215 GHz, 1000 x 280 GHz)

ACBAR



2005: 16 x 150 GHz

Niemack et al. 2008

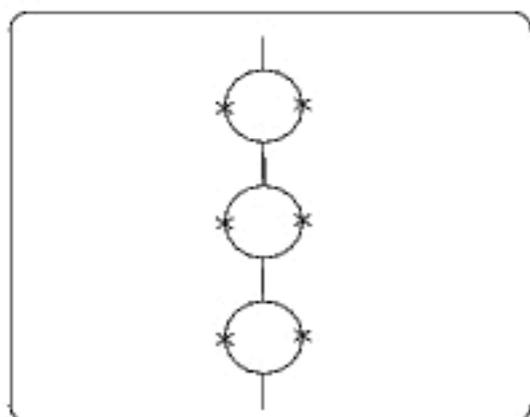
Marriage, Chervenak, and Doriese 2006

# ACT DETECTORS

Detector Lead: S. Staggs (Princeton)

NIST

4K SQUID Series Array Amplifiers



← x 32

↓ x 32

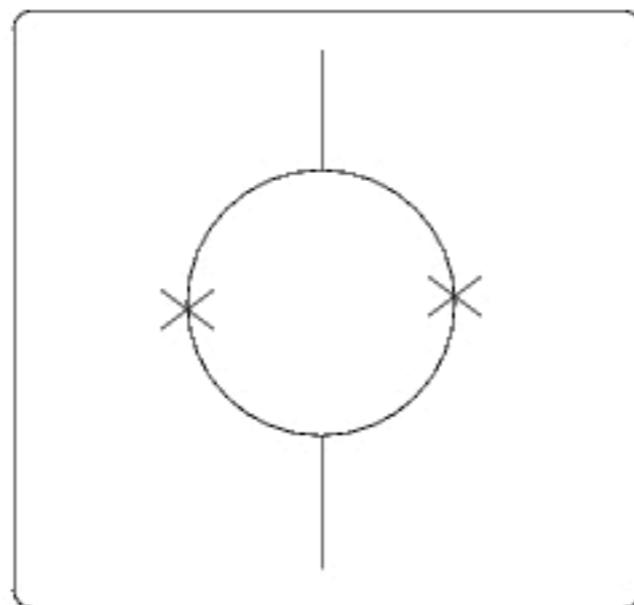
300K Backend

Multi Channel Electronics



NIST

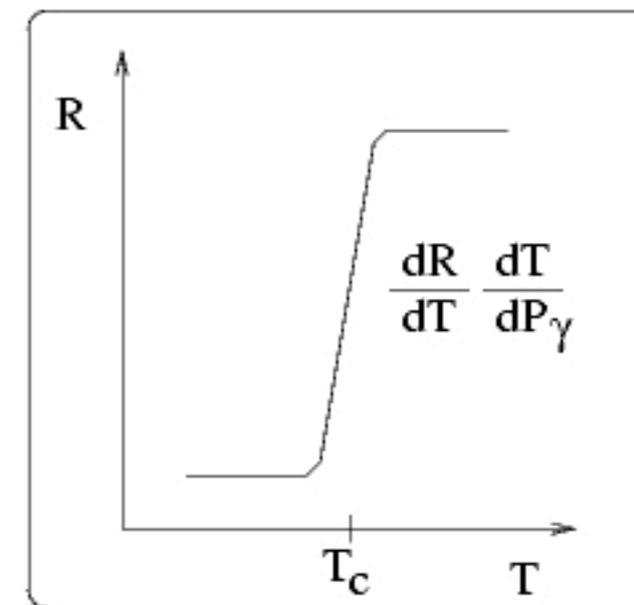
32-to-1 SQUID Multiplexor



← x 1000



Transition Edge Sensor



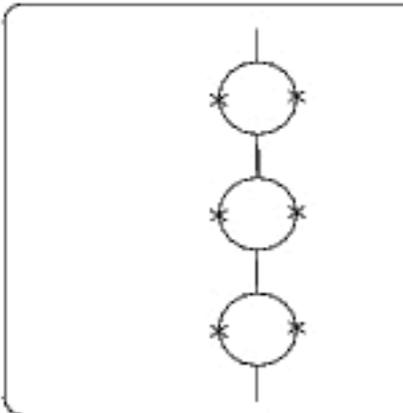
Superconducting Circuitry, Cooled to 0.3 K

Bolometers: H. Moseley (NASA Goddard)  
 SQUID Multiplexors: K. Irwin (NIST Bolometersoulder)  
 MCE: M. Halpern (UBC, SCUBA2)

# ACT DETECTORS

NIST

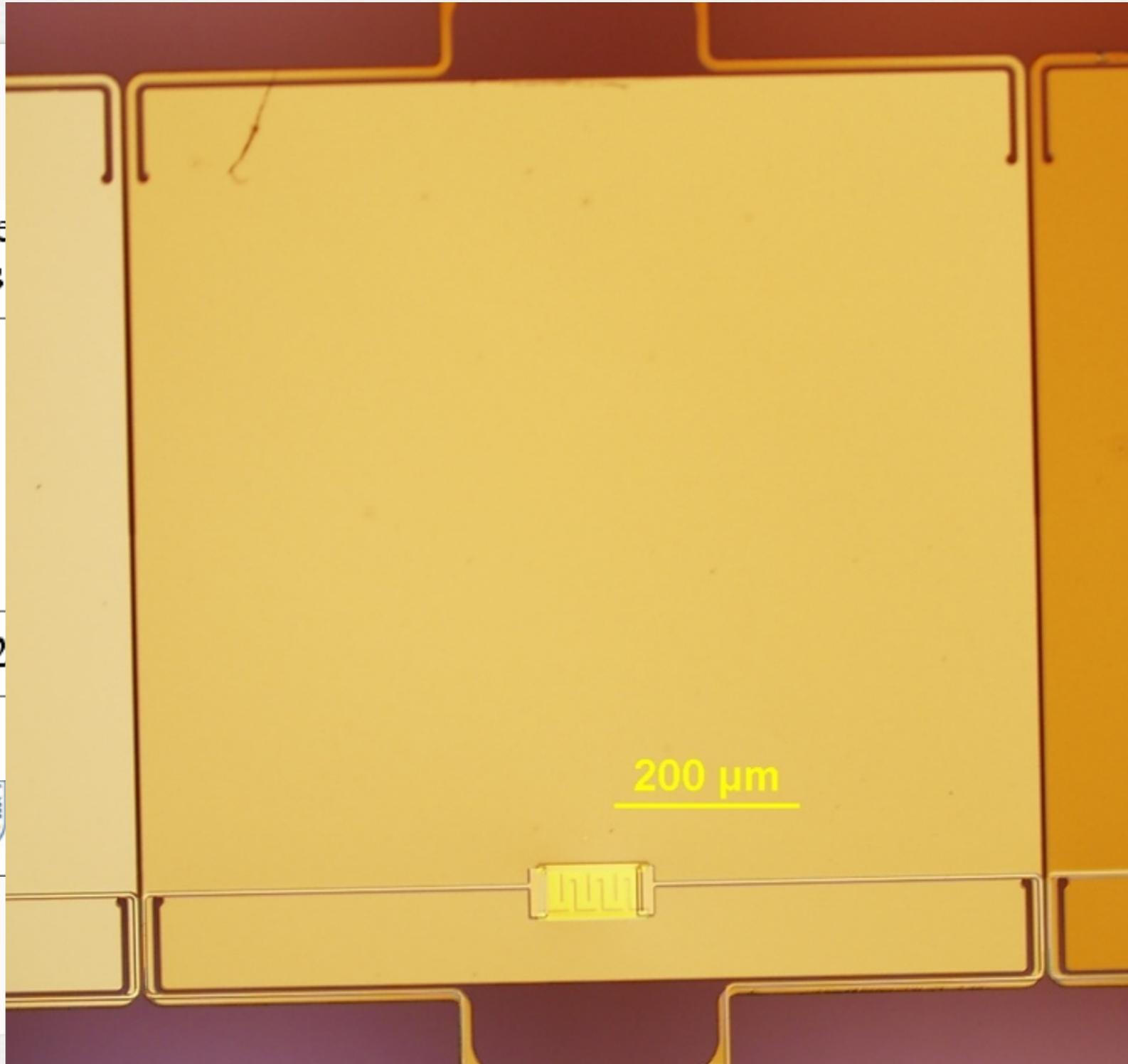
4K SQUID Series Amplifiers



↓ x 32

300K Backend

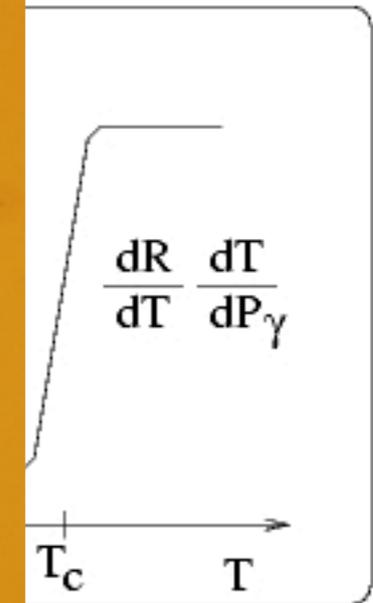
Multi Channel Electronics



(Princeton)



Edge Sensor



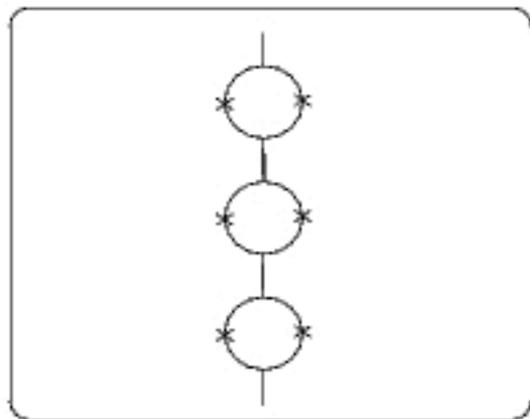
0.3 K

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NIST

4K SQUID Series Array Amplifiers



← x 32

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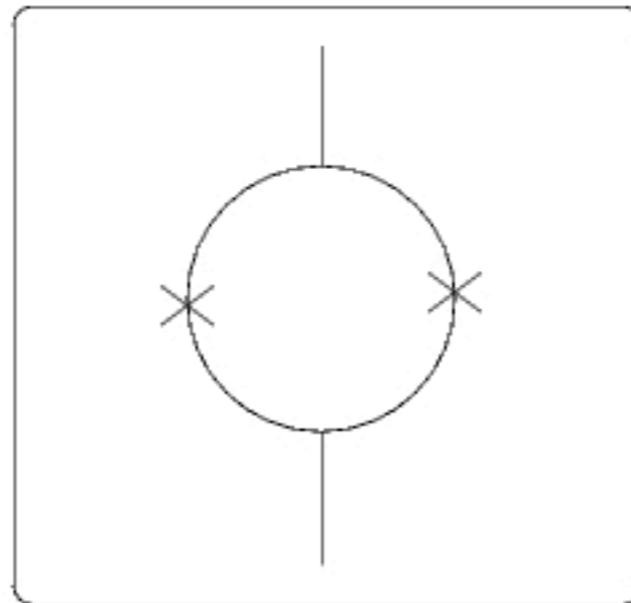
300K Backend

Multi  
Channel  
Electronics



NIST

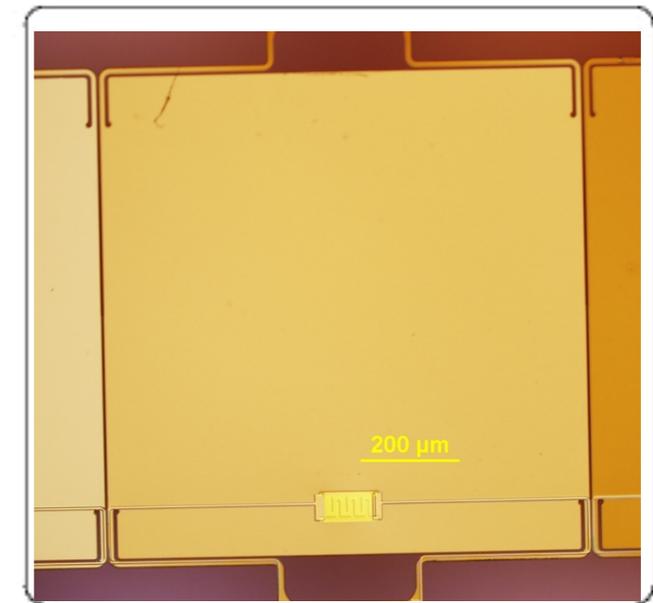
32-to-1 SQUID Multiplexor



←  
←  
←  
x1000

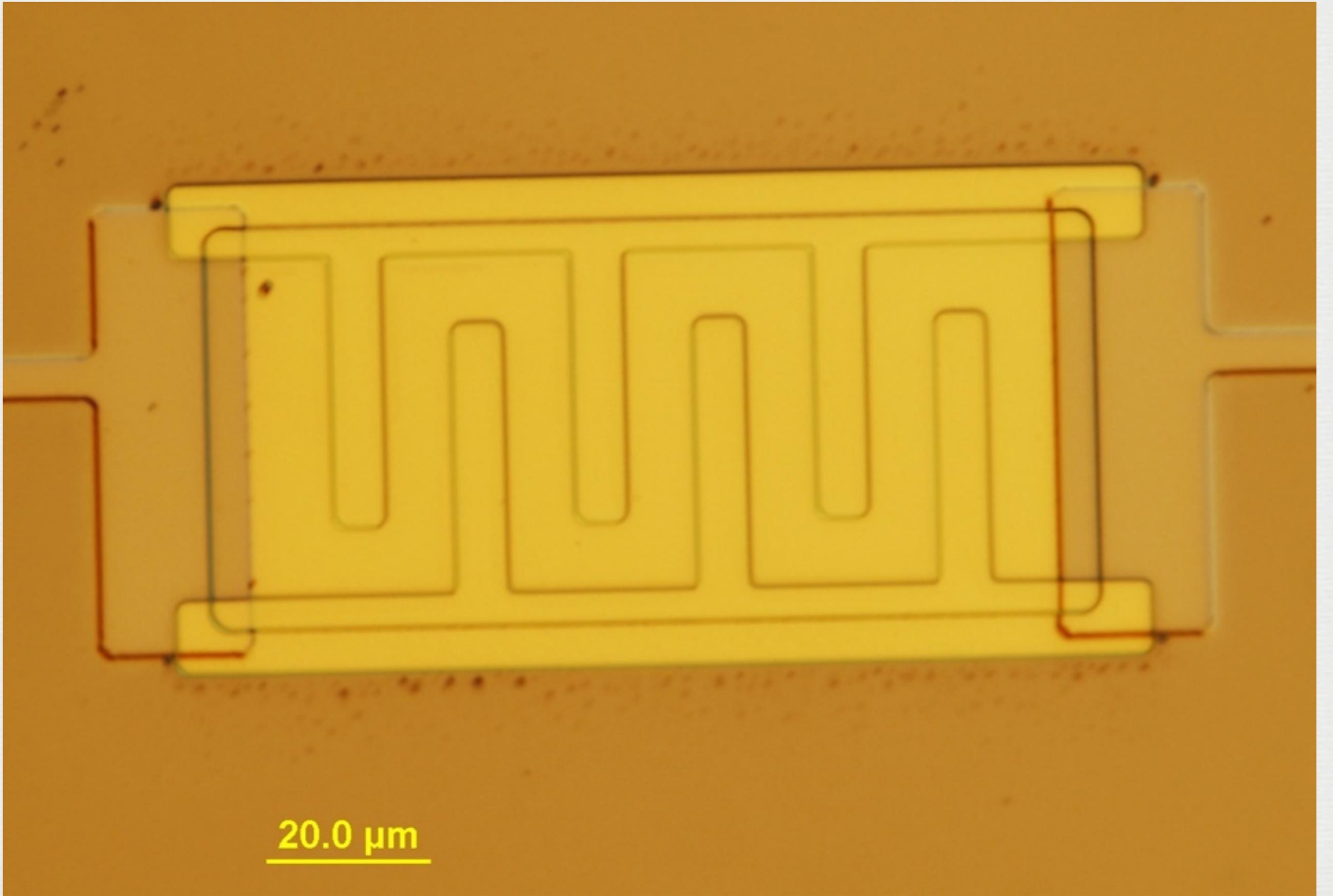


Transition Edge Sensor



Superconducting Circuitry, Cooled to 0.3 K

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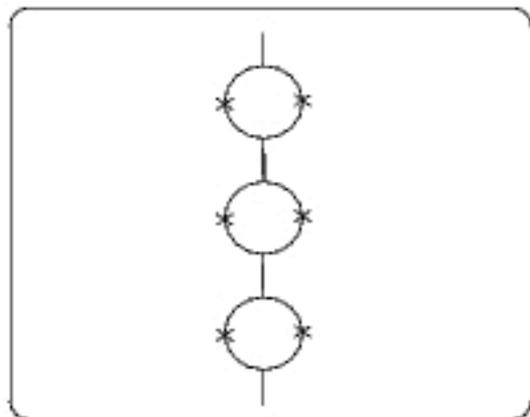
20.0 μm

# ACT DETECTORS

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NIST

4K SQUID Series Array Amplifiers



x 32

x 32

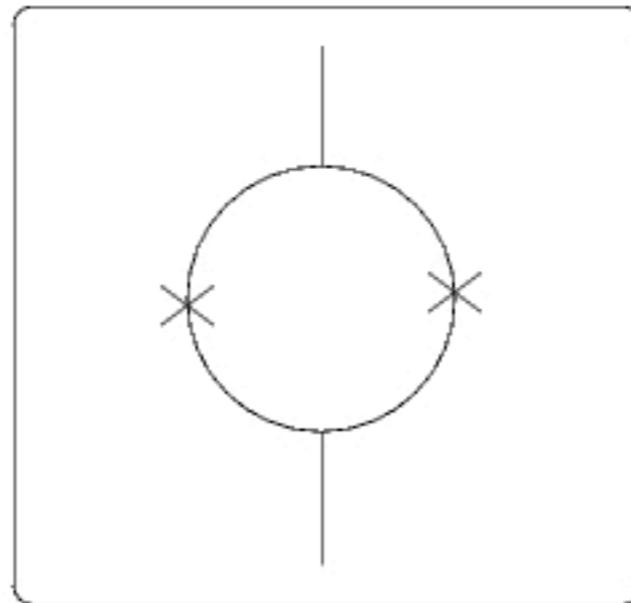
300K Backend

Multi  
Channel  
Electronics



NIST

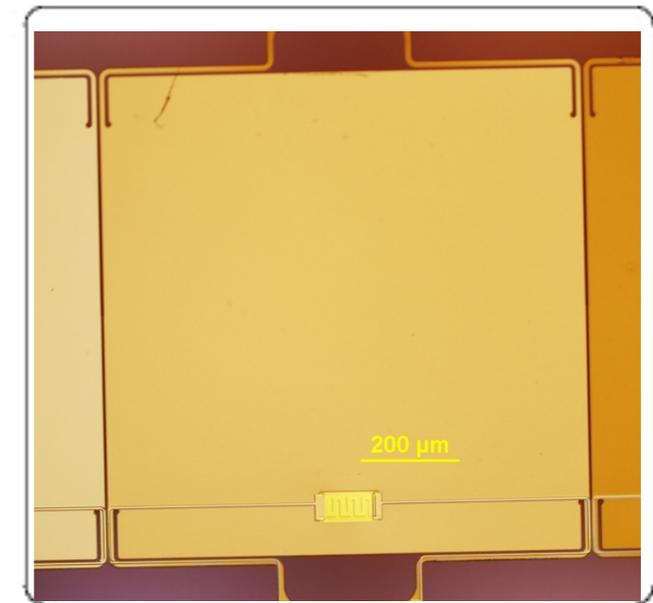
32-to-1 SQUID Multiplexor



x1000

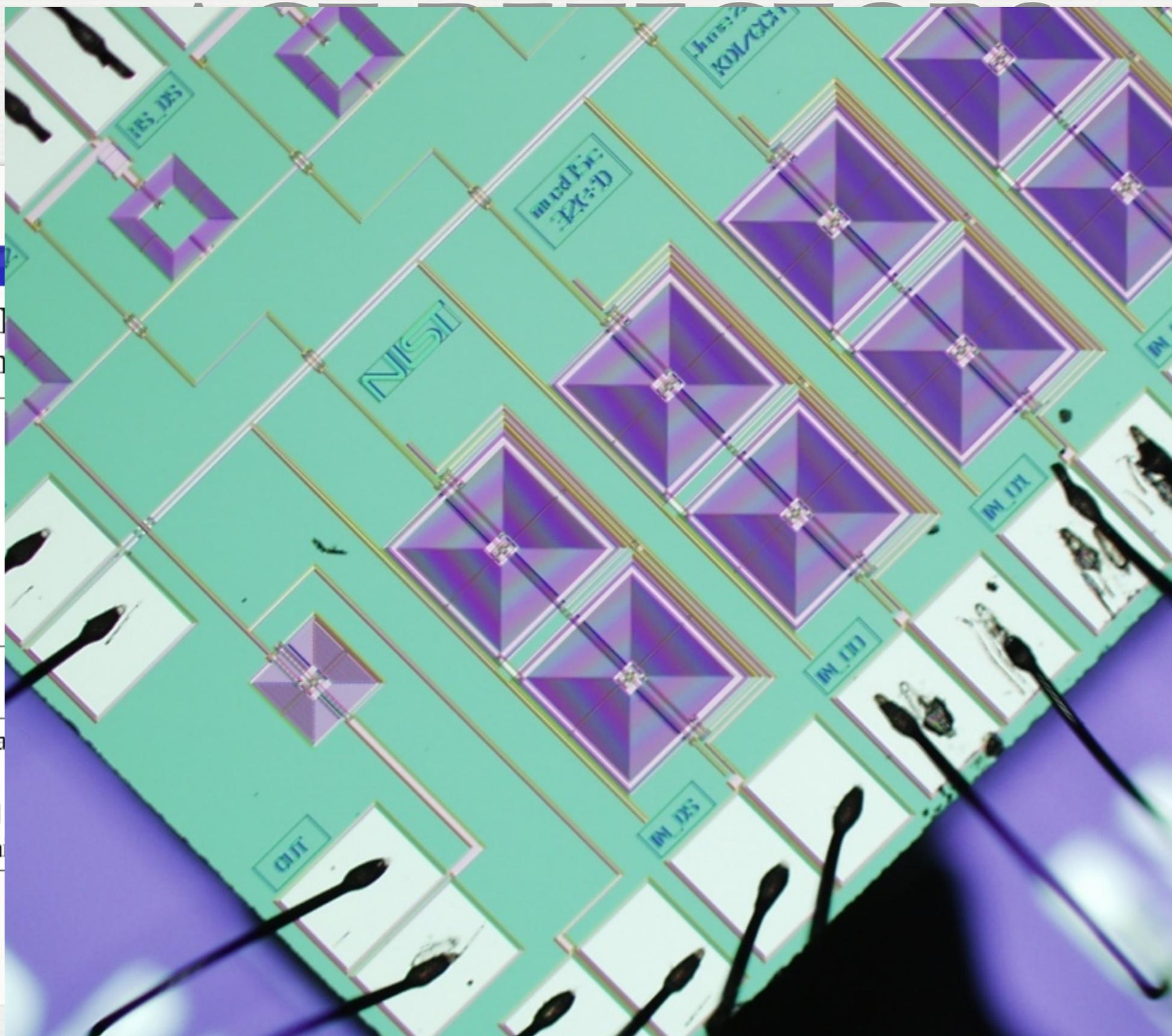


Transition Edge Sensor



Superconducting Circuitry, Cooled to 0.3 K

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4K SQUID  
Amplifier



300K Base  
Multi-Channel  
Electronics

(on)

Sensor



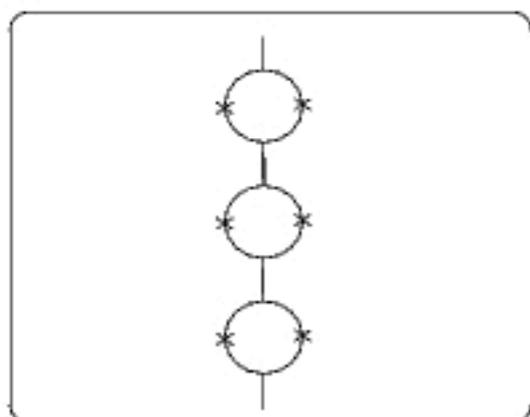
K

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4K SQUID Series Array Amplifiers



x 32

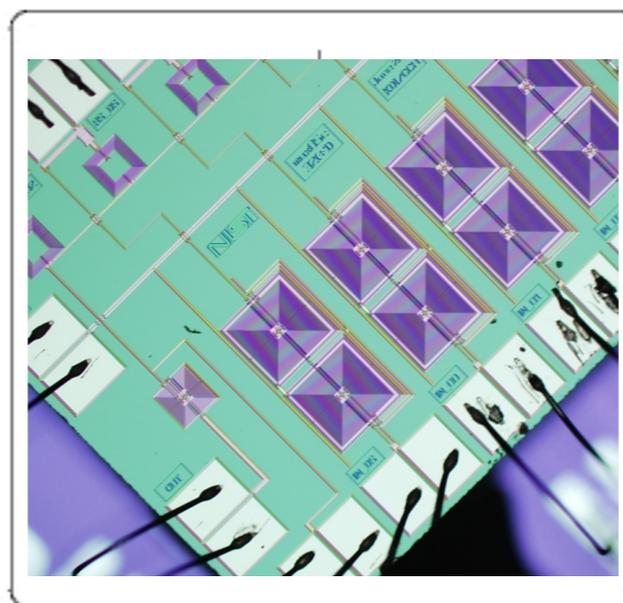
x 32

300K Backend  
Multi  
Channel  
Electronics



NIST

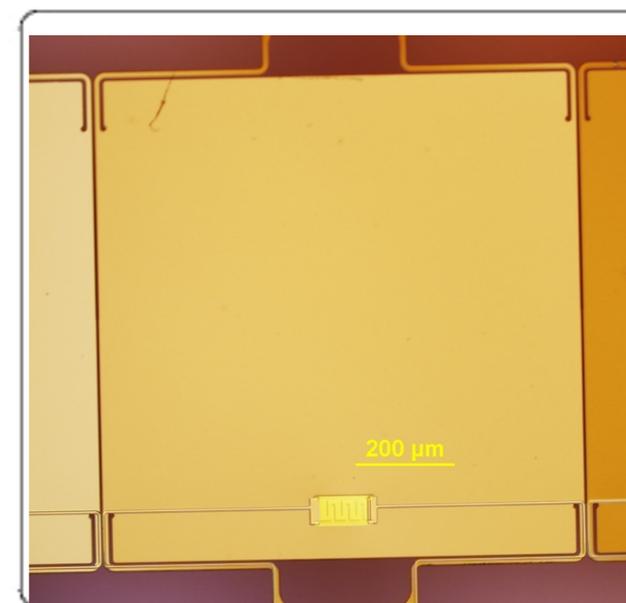
32-to-1 SQUID Multiplexor



x1000



Transition Edge Sensor

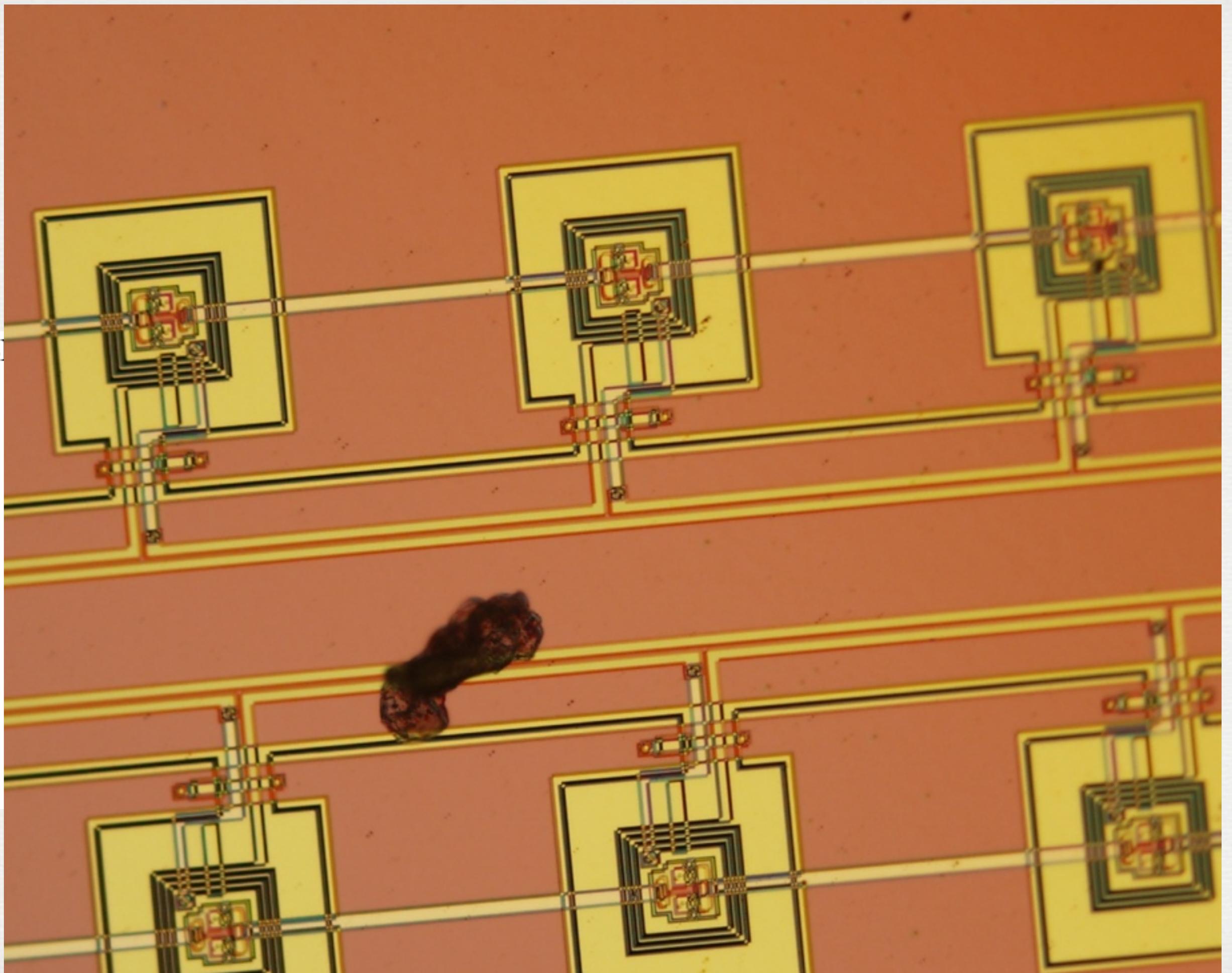


200  $\mu\text{m}$

Superconducting Circuitry, Cooled to 0.3 K

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SQUID Multiplexors: K. Irwin (NIST Bolometersoulder)  
MCE: M. Halpern (UBC, SCUBA2)

4.

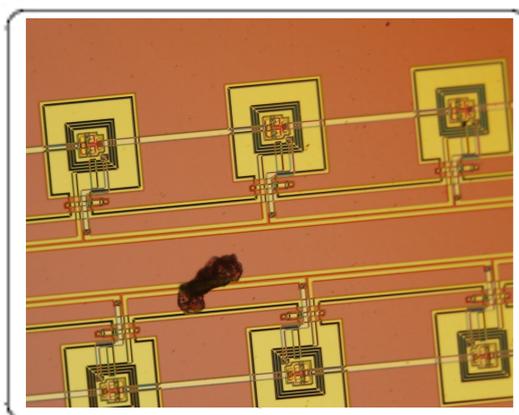


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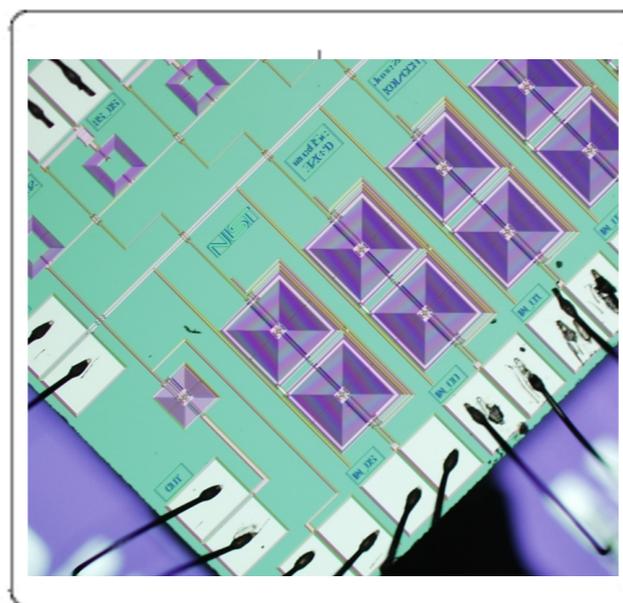
↓ x 32

300K Backend  
Multi  
Channel  
Electronics



NIST

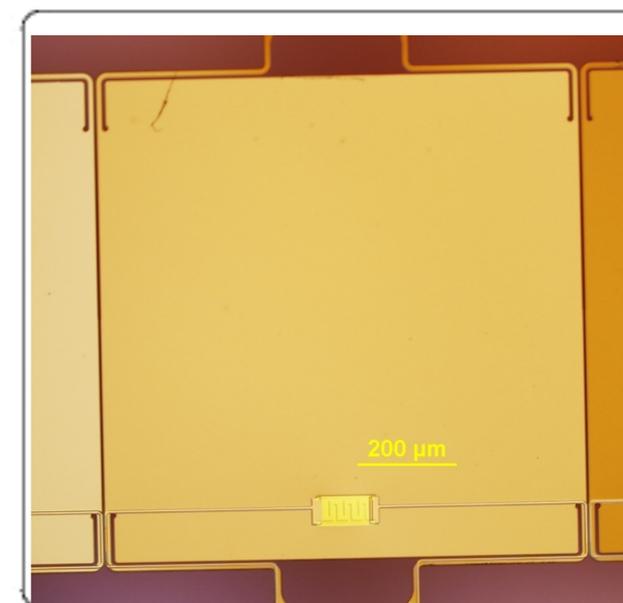
32-to-1 SQUID Multiplexor



←  
←  
←  
x1000



Transition Edge Sensor



Superconducting Circuitry, Cooled to 0.3 K

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# THERMAL SUNYAEV ZEL'DOVICH EFFECT

- Mass selects the clusters (  $F \sim M^{5/3}$  ).
- Signal is redshift independent.
- $TSZ \sim N_e T$  ( $\sim PV$  ), so probes total energy in the cluster.
- Fast Mapping -- Survey 1000+ sq. degrees

145 GHz

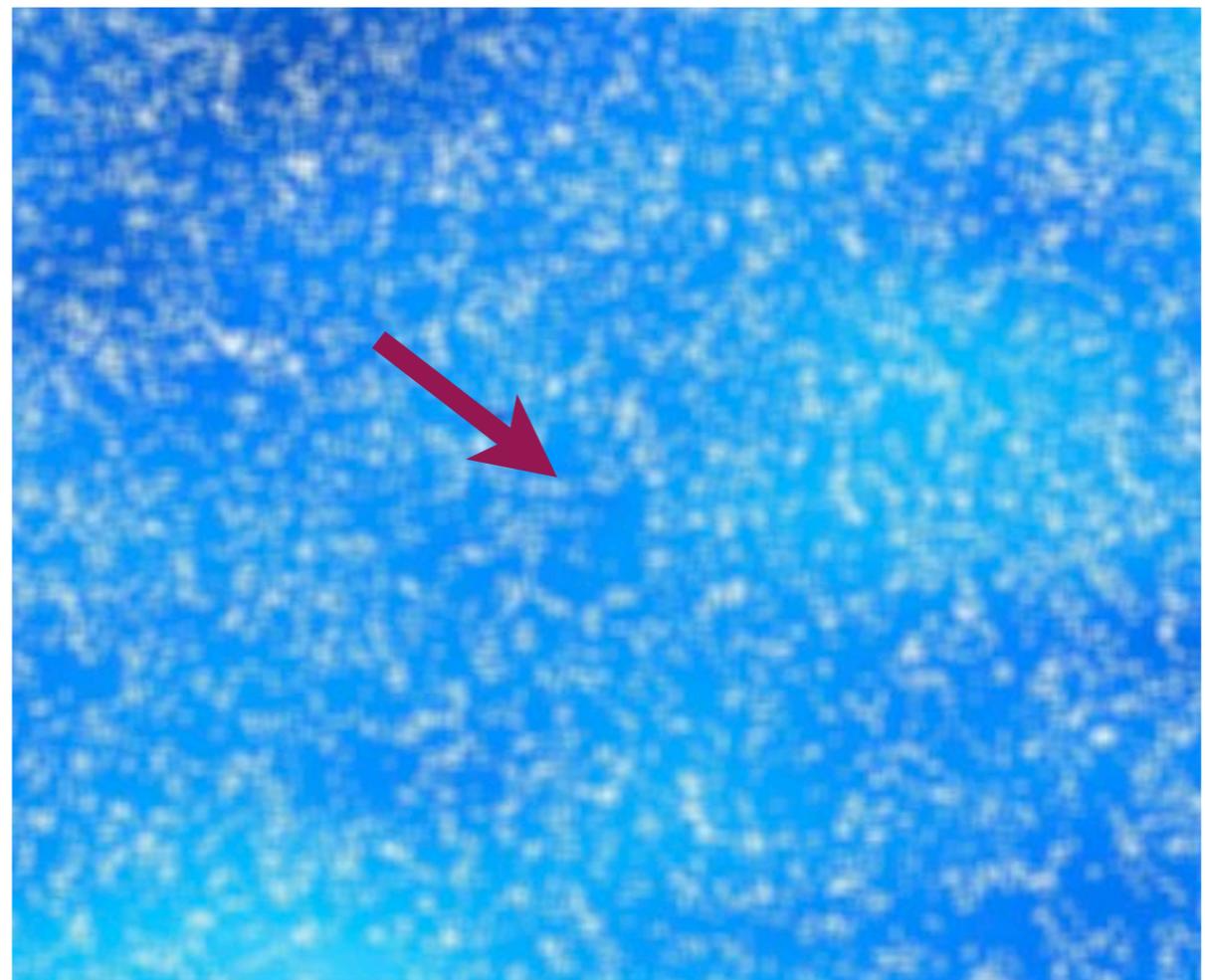


Sehgal et al. 2007

# THERMAL SUNYAEV ZEL'DOVICH EFFECT

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- Signal is redshift independent.
- $TSZ \sim N_e T$  ( $\sim PV$  ), so probes total energy in the cluster.
- Fast Mapping -- Survey 1000+ sq. degrees

215 GHz



Sehgal et al. 2007

# THERMAL SUNYAEV ZEL'DOVICH EFFECT

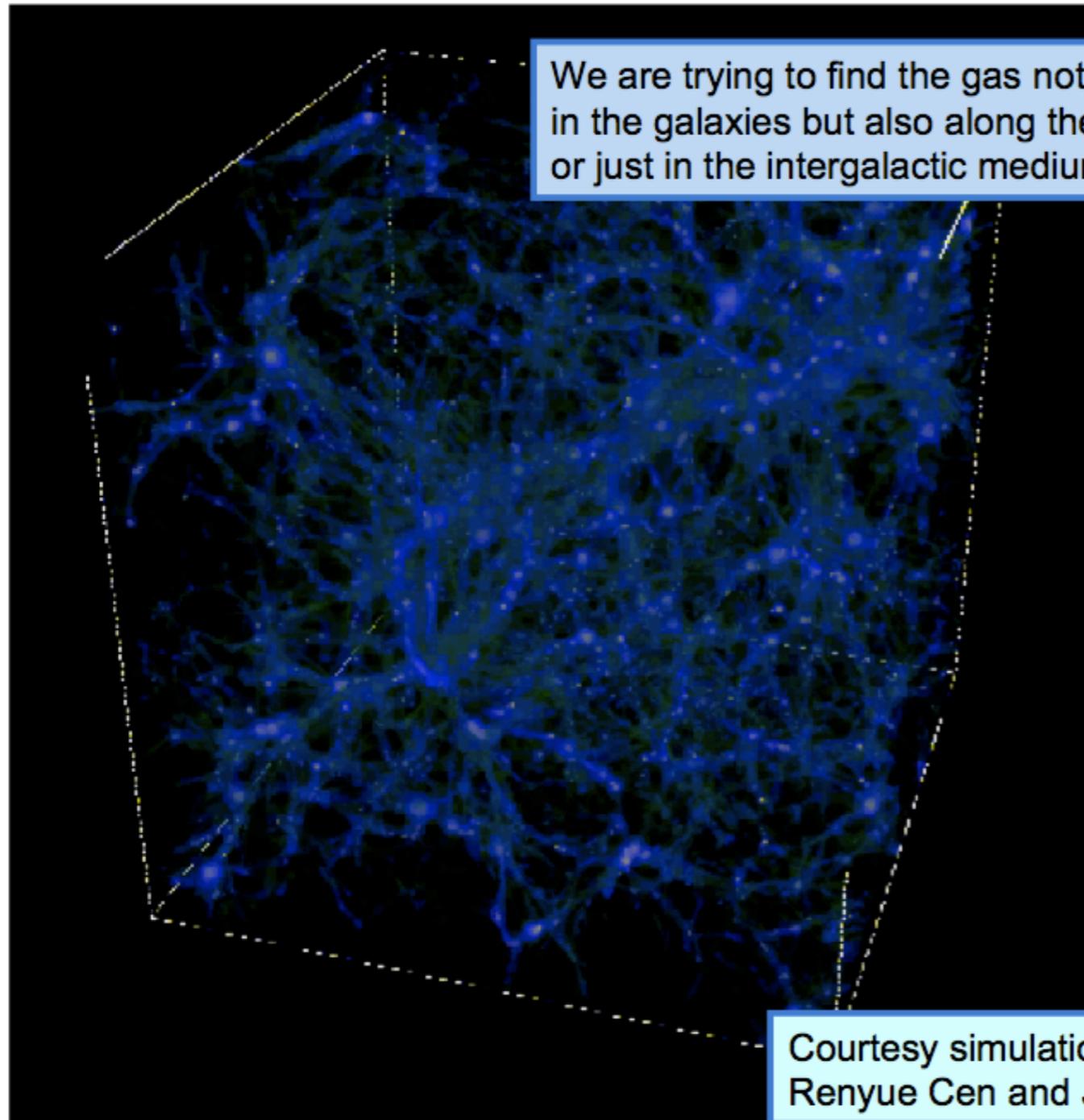
- Mass selects the clusters (  $F \sim M^{5/3}$  ).
- Signal is redshift independent.
- $TSZ \sim N_e T$  ( $\sim PV$  ), so probes total energy in the cluster.
- Fast Mapping -- Survey 1000+ sq. degrees

280 GHz



Sehgal et al. 2007

# KINETIC SUNYAEV ZEL'DOVICH EFFECT



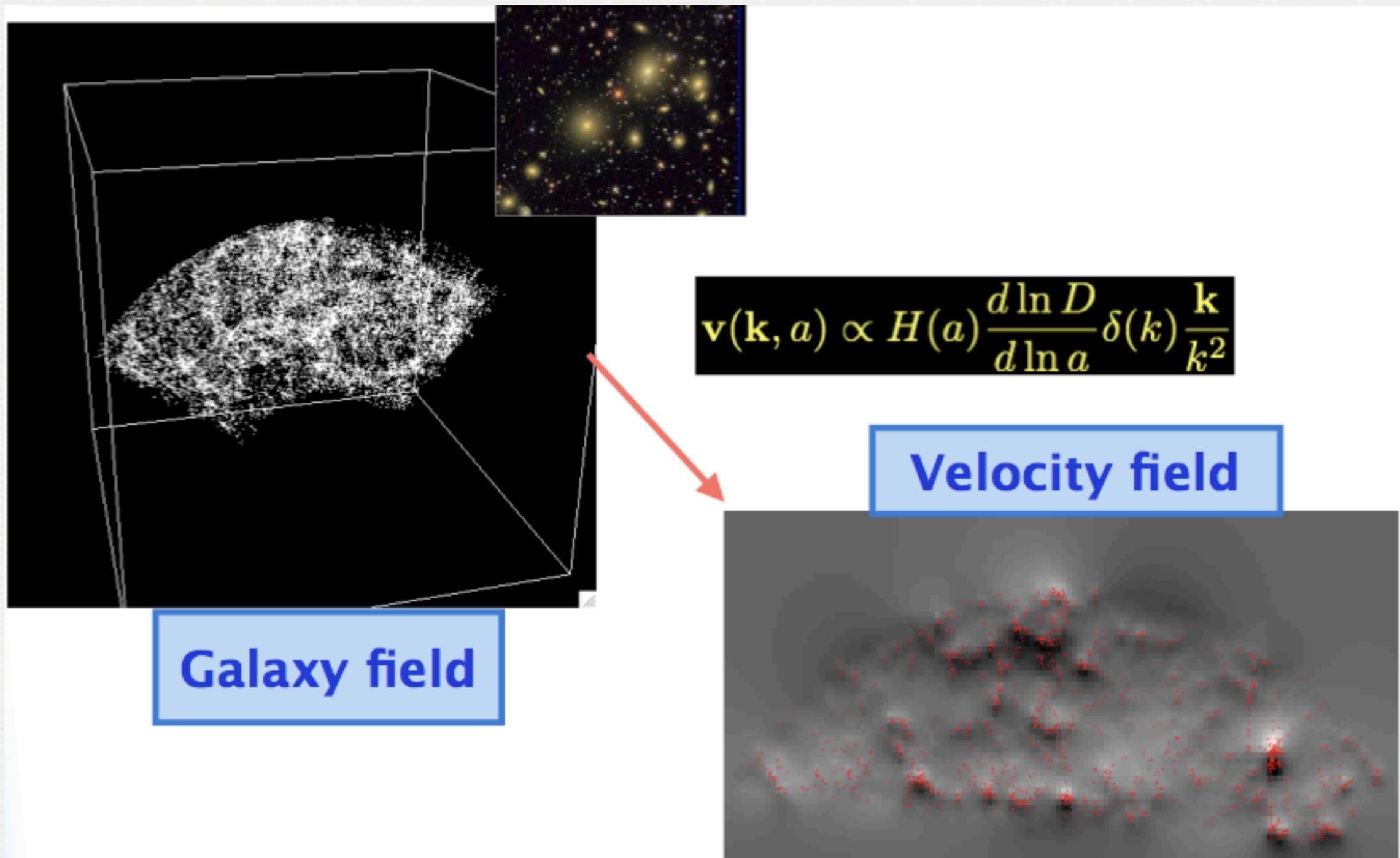
We are trying to find the gas not only in the galaxies but also along these filaments or just in the intergalactic medium!

Courtesy simulation of gas from Renyue Cen and Jerry Ostriker

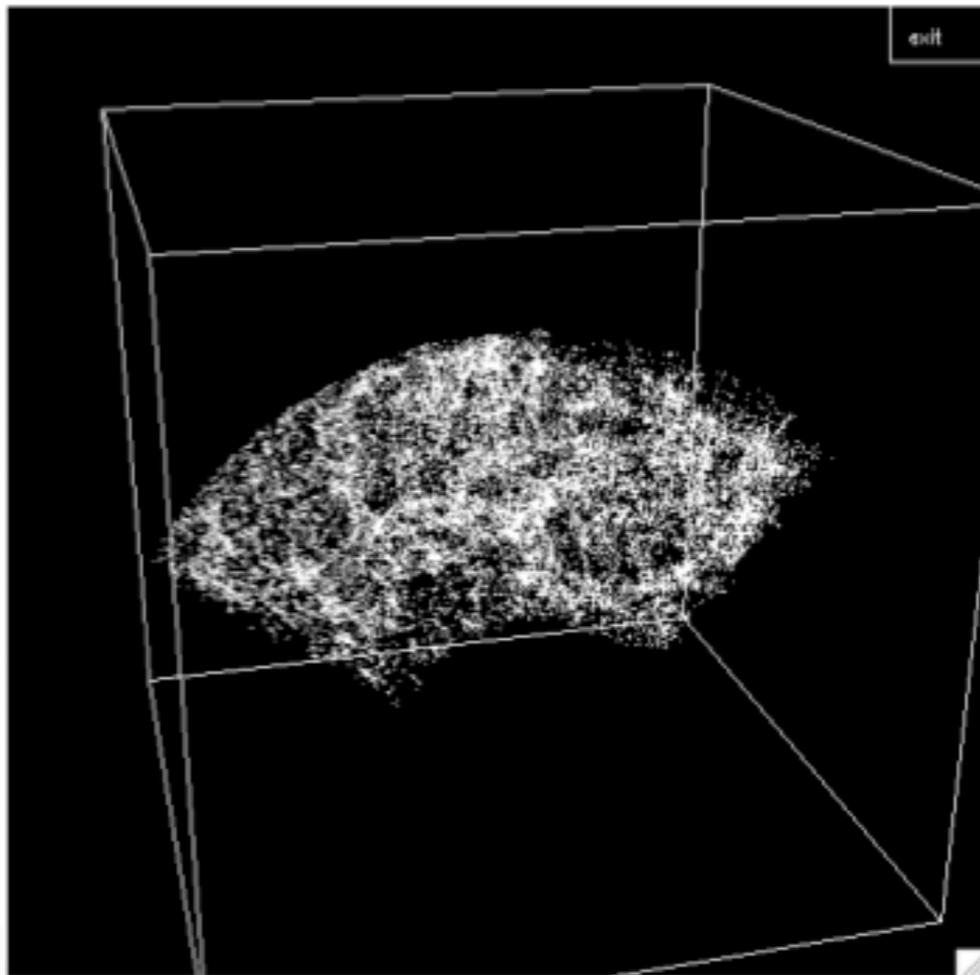
The KSZ signal is proportional to the integral of  $n_e v_e$  along the line of sight.

Because the KSZ signal does not scale with temperature, it is a natural measure for counting the baryon populations inside and outside hot clusters.

# KINETIC SUNNYAEV ZEL'DOVICH EFFECT



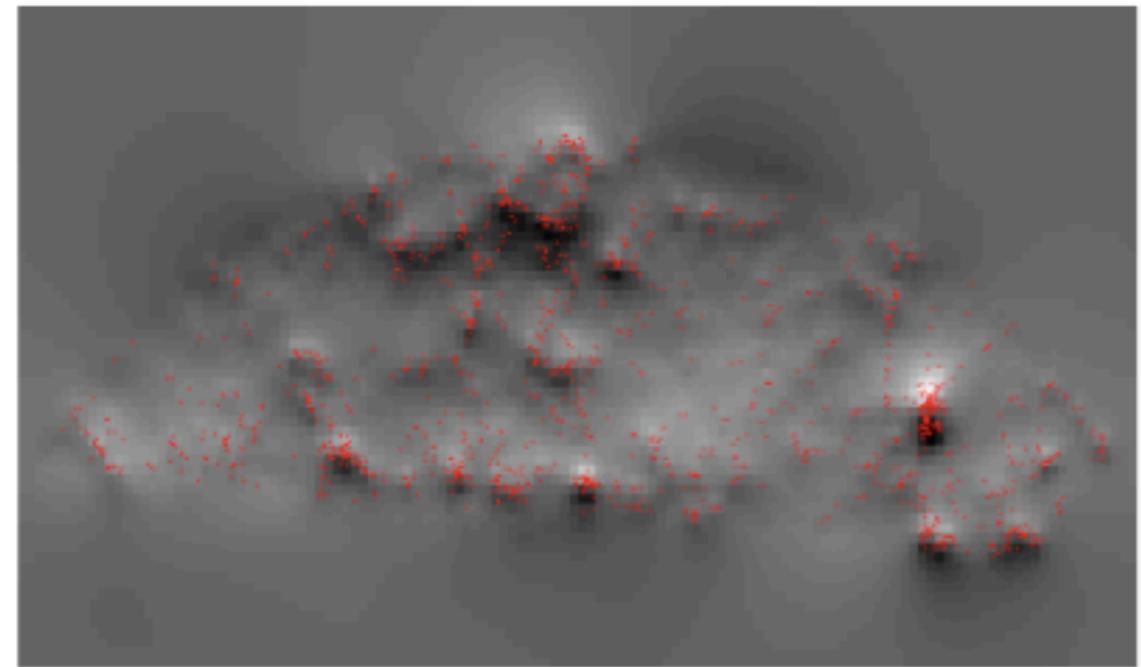
# KINETIC SUNYAEV ZEL'DOVICH EFFECT



Parameterize gas profile  
around each galaxy/region of  
interest:

$$\rho_{gas} = \rho_{gas}(r)$$

×



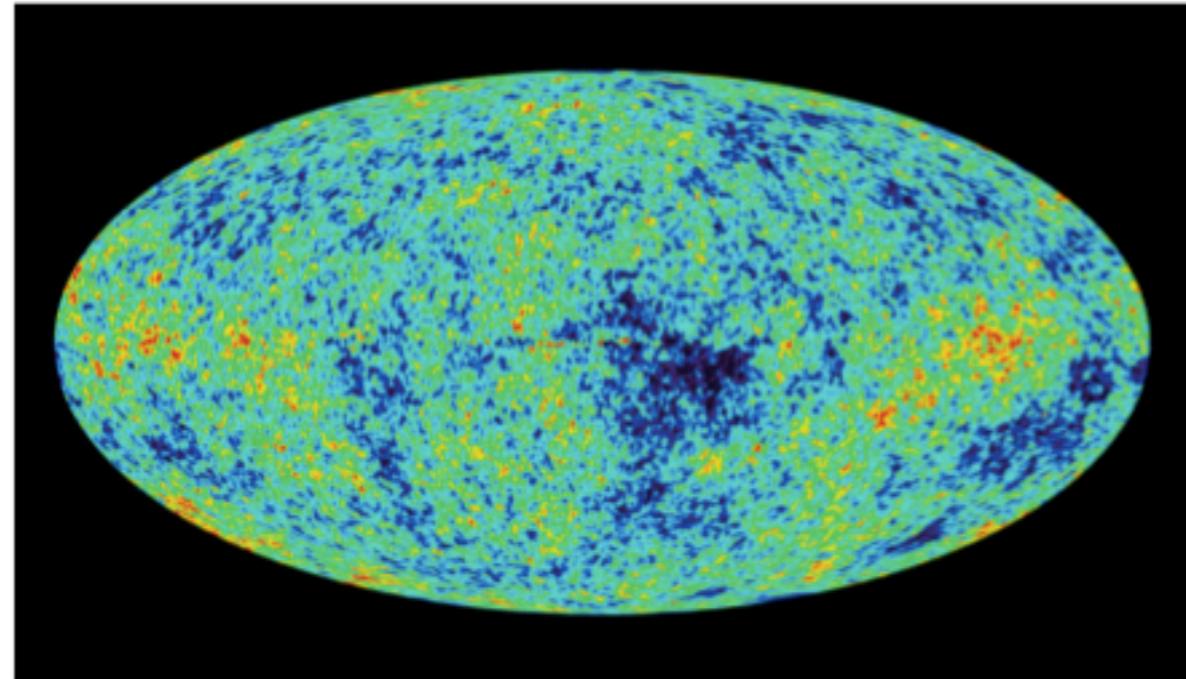
KSZ template to  
cross-correlate with  
observed CMB.

# KINETIC SUNYAEV ZEL'DOVICH EFFECT

Dedeo, Ho & Spergel 2008 (in prep)  
Ho, Spergel & ACT collaboration (in prep)

KSZ template to  
cross-correlate with  
observed CMB.

×



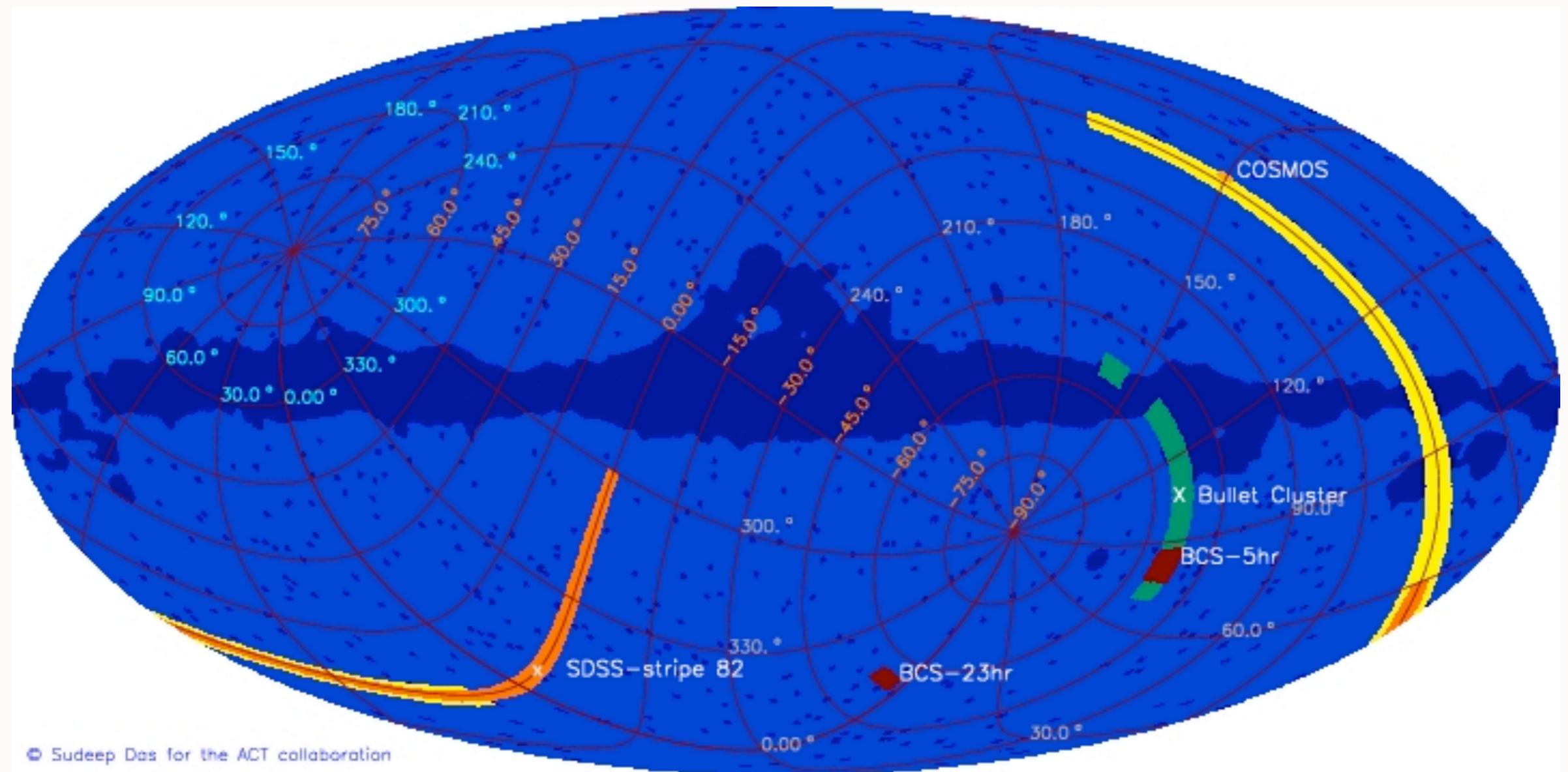
See what gas  
profile gives the best  
correlation.

$$\rho_{gas} = \rho_{gas}(r)$$

Average gas profile around  
any types of galaxies!  
or regions! [such as filaments or  
just intergalactic space]

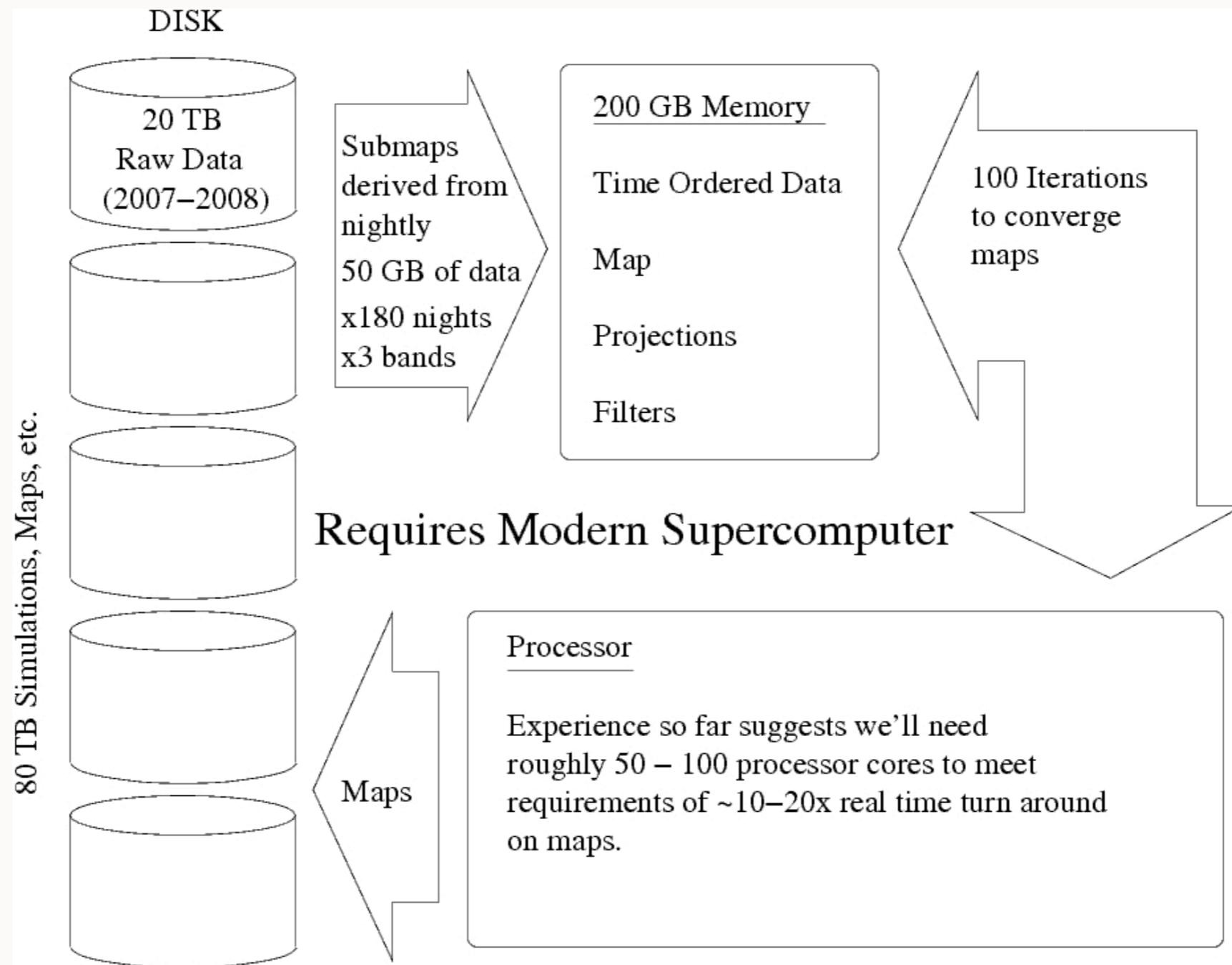
# 2007 OBSERVING

50 Nights of Observing with the 145 GHz Camera

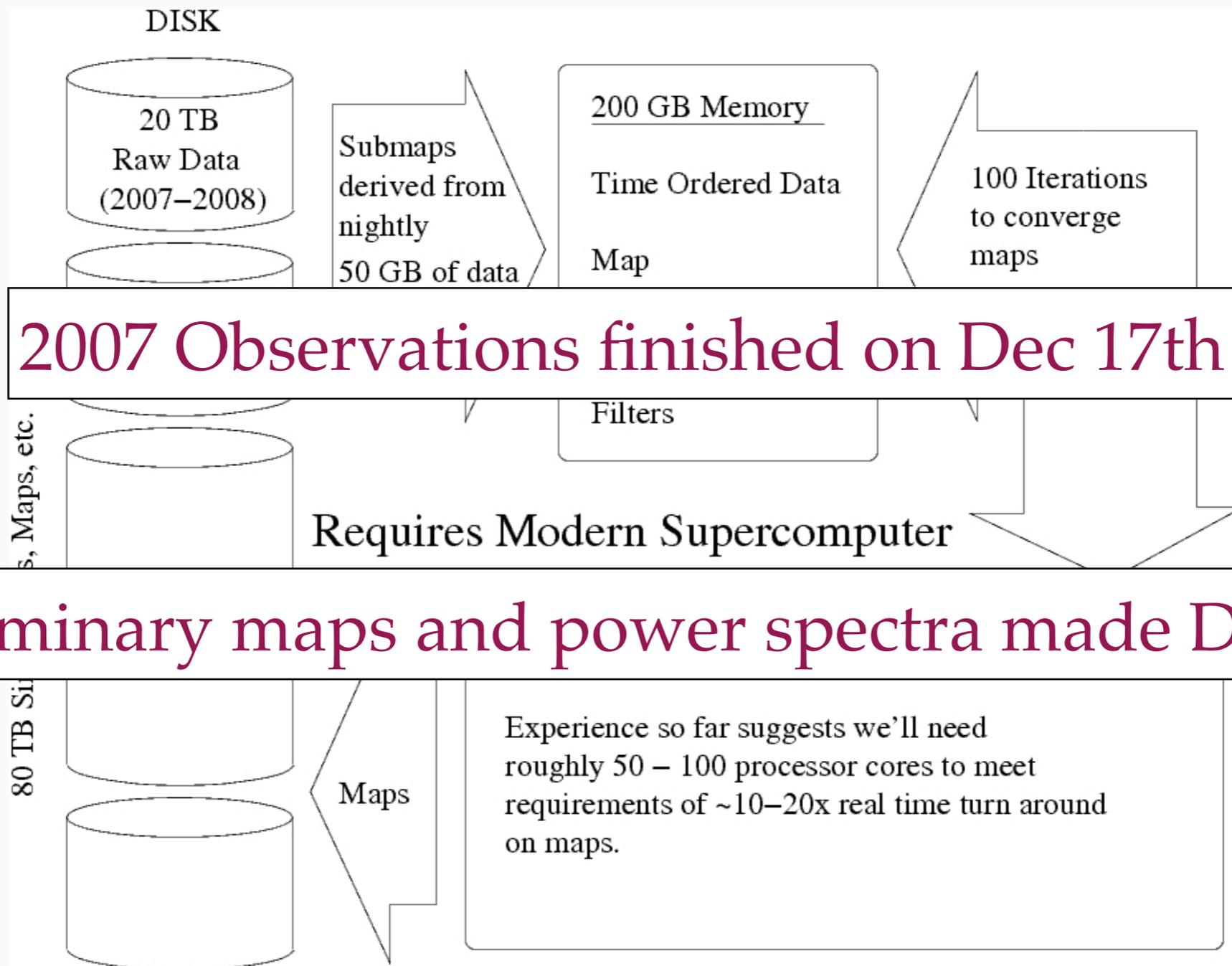


Main Science from  $\sim 100$  sq deg

# ACT MAPPING PIPELINE



# ACT MAPPING PIPELINE



# ROSAT All Sky Survey X-Ray Intensity Contours



Image Removed



ACT SZ

PRELIMINARY MAP

AS0952

~12 Minute Exposure ( < 0.1% of data )

Redshift 0.227  
(Bohringer et al. 2004)

ROSAT image was smoothed to 30".  
The cluster was unresolved by ROSAT.

# Chandra X-ray Intensity Contours



Image Removed

PRELIMINARY MAP

1ES0657 (Bullet Cluster)

~6 Minute Exposure ( < 0.1% of data )

Redshift      0.296  
(Tucker et al. 1995)



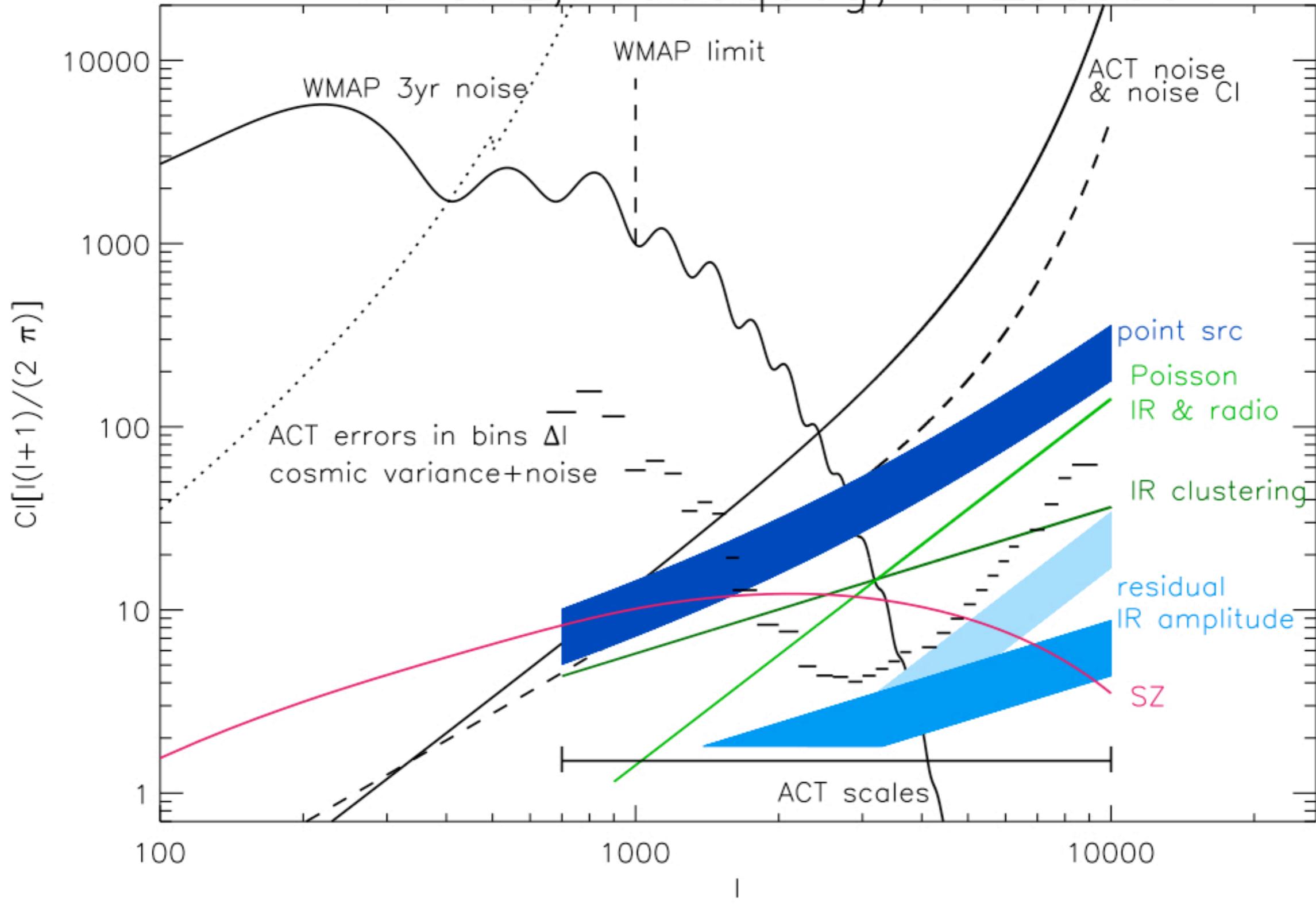
ACT SZ



Weak Lensing Convergence

(Non-SZ contours from Clowe et al. 2006)

# 145 GHz, 100sqdeg, 07\_season



# 2008 OBSERVATIONS

- 2000 Sq. Degrees Over Six Months
- Three Cameras 145, 215, 280 GHz ( 20x more data )
- Overlap with SDSS Stripe 82, XMM LSS, BCS 5 Hr,...
- Expect TSZ Detection of 100s of Clusters
- Expect KSZ Cross-Correlation Detection
- Much more...